BOOK REVIEWS

A Practical Approach to Continuous Casting of Copper-Based Alloys and Precious Metals

By Robert Wilson, IOM Communications Ltd, 2000, 288 pages, ISBN 1-86125-099-1, Price £80 (EU) / $120 (non-EU)*

This is a fascinating book, which will appeal to a wide audience from students to practitioners of continuous casting of gold and its alloys, and written in an eminently readable form. The contents and index are especially well laid out.

The first chapter highlights the major names in the world of non-ferrous metal continuous casting while discussing the basic principles of the process. Furnace construction, casting dies and cooler assembly and withdrawal mechanisms are dealt with together with safety issues and typical problems that can occur. The second chapter is a short review of heat transfer and solidification behaviour within the casting die with some worked examples of thermal efficiency of casting – the only real occasion when the author ventures into the realms of the academic.

In Chapter 3 details of some of the available equipment are presented though, unfortunately from the point of view of the gold manufacturers, these refer almost entirely to equipment used for copper alloys on a scale far in excess of the usual casting units for gold. A chapter on graphite and refractory ceramics follows and, in addition to giving details of the various grades and suppliers of graphite, the importance of using high qualities is stressed.

Chapter 5 deals with the practical aspects of casting copper and its alloys while Chapter 6, the longest chapter, covers precious metals, particularly gold. In this latter chapter there is a wealth of data on gold alloy compositions and mechanical properties and some useful casting data, though to refer to units with a capacity of 1000 kg per day as small-capacity production plant will surprise the jewellery industry. Because of the necessity of complying with caratage requirements for jewellery applications, dealing with issues such as resistance-heated or induction-heated units, the need for gas stirring of the melt and the use of pre-alloyed (grained) material for melting is to be welcomed. In fact graining and graining furnaces are given a separate section as is the need to balance the risks of undercaratage and having to remake the alloy with overcaratage and thereby giving gold away.

There is also a useful section on producing solder-cored gold rod for chain making by continuous casting, and on casting of carat gold tube, especially on dealing with tube breaks during casting. Finally, casting of a number of industrial alloys (gold-tin, gold-germanium, gold-silicon and gold-beryllium) is described.

The book has a final chapter on other non-ferrous metal alloy systems.

All in all the book is a valuable, handily-sized and very well presented publication which is obviously written by an expert in the field. It is particularly useful in the way it makes recommendations and deals with many of the problems likely to be faced during continuous casting. However it is a pity that, although it makes extensive use of schematic diagrams, there are no photographs of casting machines in operation.

Peter Raw
Bookham, Surrey

* Shelton House, Stoke Road, Shelton, Stoke-on-Trent ST4 2DR, UK. Fax: +44 1782 221722; E-mail: Orders@materials.org.uk

King Croesus' Gold : Excavations at Sardis and the History of Gold Refining

Edited by Andrew Ramage and Paul Craddock, published for the Trustees of The British Museum by the British Museum Press in association with the Archaeological Exploration of Sardis, Harvard University Museums, 2000, 272 pages with 240 illustrations (40 in colour), ISBN 0 7141 0888 X, Price £ 45.00

This book tells the fascinating story of a gold land in antiquity, the State of the famous King Croesus (562-574 BC) in Sardis, Lydia in today's Western Turkey. He was the prototype of wealth, not only in antiquity but still in modern times. Croesus invented the use of coins made predominantly from gold and silver and their alloys, with a few per cent of added copper. The coin production began from alluvial gold dust obtained from the river Sardis: he then soon realised that if he wanted to make quality products he needed quite a good quality control system to ensure that the coins were as constant as possible in weight and purity. As we now know, he succeeded impressively in meeting both these requirements: *eg* his 1/3 staters of 4.76 g vary by only 10 mg at the most, and after striking, his golden coin blanks do not show any edge cracking at all – a good indication of top quality. The 400 years younger Celtic gold coins – the Regenbogenschüsselchen – possess extensive cracking along grain boundaries, arising from the presence of sand or other impurities in the blank or the alloy.

Even though processes for the separation of gold, silver and copper in their alloys were known in both East and West much earlier than Croesus, as

discussed by Paul Craddock, nevertheless Croesus was the first to run them on an industrial scale. For this he needed chemicals such as salt (from rock salt or seawater?), auxiliary metals such as lead, furnaces capable of reaching 800-1200°C, and experienced staff. The evidence of the operations and chemicals were found all over the excavation site at Sardis: in soil, broken pieces of pottery, bricks, and the 'tuyeres' used to provide the furnaces with oxygen from the air for the oxidation processes.

We must be grateful to Professor Ramage from the Harvard-Cornell excavation team at Sardis that when he found the remains of metallurgical processing, which he could not explain, he called in British Museum experts from their Department of Scientific Research to assist in explaining the significance of their finds. This resulted in an admirable interdisciplinary collaboration which resulted in a number of publications in addition to this book. The results will also have important relevance to other sites.

The book has ten chapters, and starts with a list of contributors: two from the Technical University of Istanbul and Bosphorus University, one from Cornell and seven from the British Museum. A Prologue provides an outline of the aims of the project. In Chapter 1, entitled 'Golden Sardis', Andrew Ramage describes the city's geographical and historical background. The more technical information starts with Chapters 2 and 3 by Paul Craddock : 'Historical Survey of Gold Refining'. The first part concerns 'Surface Treatment and Refining Worldwide, and in Europe Prior to AD 1500', and Part 2 is 'Post Medieval Europe': a total of 45 pages including many illustrations, citations and 83 references. This overview clearly shows that the basics of the process have remained unchanged for thousands of years until the 19th century when the Miller and Wohlwill processes based on chlorination and electrolysis respectively were introduced; then liquid/liquid extraction followed some 50 years later. Only then was it possible to remove the 'platinoid' osmium/ruthenium/iridium alloy globules.

Andrew Ramage describes 'The Excavations and Finds' with many plans, drawings, and photos of cupellae, tuyeres, litharge cakes, and parting vessels; and to the archaeologists delight there is an altar in the middle of the gold works: it was apparently necessary to enlist the support of the gods to achieve success in such complicated operations! A nice piece of art is an animal, about 2 cm long, made from polished rock crystal, and for the metallurgist a complete cementation pot, still containing its charge: a pleasure indeed. For the study of gold foil one should refer to later chapters.

The first contribution from the laboratory is by N.D. Meeks in the form of an extensive and detailed report on 'Scanning Electron Microscopy of the Refractory Remains and the Gold'. The quality of the photographs is excellent: they show gold-silver globules, silver chloride, and the lead/silver alloy embedding themselves into ceramics. The gold alloys have a silver content of between 10 and 30% and a copper concentration near 1%. Very appealing in their appearance are the spongy-porous structures of the gold foils, which are caused by the outward diffusion of the silver to its reaction sites with oxidants and the chloride at the surface or on the grain boundaries: the gold/silver system is ideal for the observation of the Kirkendall effect. The structure is also typical for depletion gilded surfaces, and it even shows up in amalgam gilding after evaporation of the mercury. A good coloured photograph is useful for seeing the platinoid globules mentioned earlier, in the Pactous alluvial gold; and there is a black and white picture of the 'cabbage' structure where gold granules have torn themselves from the river.

A.P. Middleton, D.R. Hook and M.S. Humphrey showed in their contribution entitled 'Scientific Examination of Some Ceramic Materials and Samples of Litharge' that most of the ceramic fabric came from local sources, and that some was deliberately selected from heat-resistant magnesium-rich clay.

A short chapter by M.R. Cowell and K. Hyme, 'Scientific Examination of the Lydian Precious Metal Coinages' reveals the incredibly small scatter in the weight of small coins, as mentioned in the first paragraph above. Did the Lydians have balances and coin moulds like the later Celts? Compositions are also listed: these are close to those of the gold leaf. Platinoid globules are also present in the coins, but it would be difficult to deduce too much from their occurrence: their metallurgy is very complicated.

In Chapters 8 and 9, Paul Craddock discusses 'Replication Experiments and the Chemistry of Gold Refining' and 'Examination of the Sardis Gold and the Replication Experiments' (together with A.E. Geekmuir, H.Ötzbal and N.D. Meeks). They produced structures in the surface of gold which are indistinguishable from their historic counterparts, as indicated by the SEM photographs and the 'sponge' and diffusion profile curves.

Chapter 10, by Paul Craddock, on the 'Reconstruction of the Salt Cementation Process at the Sardis refinery' is related to Chapters 8 and 9. The analysis of the refined gold – in antiquity by touchstone – confirmed its high purity.

In the 'Epilogue', written by both main authors the 'Significance of the Sardis refinery in the Classical World' is discussed. Their last sentence is "At present our discoveries offer the only archaeological evidence to confirm the ancient tradition". The 'Inventory and Descriptions of the Gold Samples' by Andrew Ramage describes more than 50 samples on 6 pages, nicely illustrated, as is 'Inventory and Descriptions of Finds of Equipment and Supplies' by the same author.

Three contributions by Paul Craddock, 'Early History of the Amalgamation Process', the last plant for which has just been torn down in Freiburg/Saxonia, Germany; and authoritative articles on 'The Platinum Group Element Inclusions' and on 'Assaying in Antiquity' conclude the book's scientific part.

Before we arrive at the last page, there is an anonymous note: 'Concordance between Sardis Excavation Codes and British Museum Codes, which are apparently important in the British Museum. There is a technical Glossary of 4 short pages, mostly explaining technical names of modern laboratory instruments and methods (*eg* XRF analysis) and it should have included metallurgical terms as well! There is a Bibliography and an Index: both short and condensed, but complete.

To summarize, this is a fine and delightful book, with excellent printing, teaching its reader, in its widest sense, the basis for our modern chemical and metallurgical industry. The reviewer stands in admiration of his colleagues in Hephaistos in Lydia. To the archaeologists, metallurgists and all involved in the 'Industrial Archaeology at Sardis' and in the book, he wishes the very best. In the next book, however, he would like to know how the coins were actually made in or around Sardis. GLÜCKAUF

Christoph J Raub
Schwäbisch Gmünd

The Power of Gold

The History of an Obsession

By Peter L Bernstein, John Wiley and Sons Inc, 2000, 432 pages, ISBN 0-471-25210-7, Price £17.99

At the beginning of this book it is stated that it tells the story of how people have become intoxicated, obsessed, haunted, humbled, and exalted over pieces of metal called gold. The book describes in a very readable and captivating style the wide spectrum of interactions which gold has had in the history of mankind, and how many famous individuals have played a part in various developments. A Prologue entitled 'The Supreme Possession' sets the scene, and then there are three major well integrated parts to the substance of the book: *ie* 'A Metal for All Seasons', 'The Path to Triumph' and 'The Descent from Glory', each describing in a fascinating and very readable way the most important themes associated with gold. Finally there is an Epilogue, again entitled 'The Supreme Possession' but this time ending with a question- mark?

In the 'Metal for All Seasons' Section there are nine chapters and in 'The Path to Triumph' seven. Each of these chapters deals with an historial phase in the development of the search for gold and its uses and impact on civilization, from ancient until modern times. In the Third Section, 'The Descent from Glory', there are four chapters and the discussions are largely centred around the gradual decline of gold in its importance to banking systems.

When describing historical matters, from ancient Egyptian, Greek, and Roman times, and biblical references to the metal; to the comparatively recent discoveries of gold at, for example, Sutter's Fort in California in 1848; the text reads as an accurate historical story. When discussing the pros and cons of the gold standard the economic arguments are presented in a way which will be understood by a wide readership.

The role played in the gold story by the prominent English scientist, Sir Isaac Newton makes fascinating reading. Whilst Warden of the Mint in London he was transformed from an uncommunicative, introverted, unapproachable Puritan scientist, and passionate believer in alchemy, to an active politician and prominent civil servant, wrestling with economics, which he found a lot more difficult than physics!

The only possible weakness of the presentation detected by the reviewer is a little inaccuracy in the scientific descriptions. For example on page 245 it states that "silver lacks gold's glamour because it tarnishes so much faster than gold", whereas it could have stopped at "..... because silver tarnishes"; and on page 19 it states that "... gold is too scarce to have many uses" : the truth is that the Platinum Group Metals (PGMs) are only available in much smaller quantities, but have many more uses, because the technical attributes of the PGMs have been much more thoroughly investigated than for gold.

There are 125,000 tons of gold in existence: much more than all the platinum metals put together. In fact, one year's production of gold is more than all the platinum metals that have ever been produced. Bernstein tends therefore to underrate the potential for the industrial use of gold, which deeper scientific research into its chemical and physical properties in the years to come will promote.

The rationale for defining the purity of gold in terms of carats, based originally on the uniform size of the fruit of the leguminous carob tree, every single pod of which weighs one-fifth of a gram, is given. The grain has now replaced the carat as the conventional unit of weight.

Gold has been a coveted, celebrated and inglorious asset for a very long time, and it has played an important role in shaping history. Frantic speculators pushed the price of gold up to $850 an ounce in 1980, just as their counterparts twenty years later have driven Internet stocks to exorbitant heights! Gold has commanded more respect than any other substance in history. There has been a constant tension between the use of gold for adornment (arising from its unique beauty and attractiveness) and its use as money.

Coins came in around 700 BC, 2,000 years after gold was used as a monetary metal and were an ingenious innovation designed to get round the tedious business of weighing and checking purity, but some of them were faked (see report on meeting in London : page 138 of this Issue) and this introduced new problems.

At the end of the book there is a good bibliography and the index is adequate. The book is recommended reading for anyone interested in any of the many aspects of gold and its lasting potential to influence the course of human endeavours.

David Thompson